Amendments to the Claims

This listing of the claims will replace all prior versions, and listings, of claims in this application.

Claims 1–15 (canceled).

Claim 16 (currently amended): A method for preparing a composite cathode active material for a lithium secondary battery, the method comprising:

producing a first lithium metal composite oxide in a reactor by (a) precipitating a first metal composite hydroxide from a first mixture of a first metal precursor, a first aqueous ammonia solution and a first basic solution, and (b) mixing and reacting the first metal composite hydroxide with a first lithium precursor to form the first lithium metal composite oxide;

producing, separately from the first lithium metal composite oxide, a second lithium metal composite oxide by (a) precipitating a second metal composite hydroxide from a second mixture of a second metal precursor, a second aqueous ammonia solution and a second basic solution, and (b) mixing and reacting the second metal composite hydroxide with a second lithium precursor to form the second lithium metal composite oxide; and

after separately producing the first and second lithium metal composite oxides, mixing the first and second lithium metal composite oxides to form a composite cathode active material for a lithium secondary battery, wherein

the first lithium metal composite oxide has a mean particle diameter that is less than 90% of a mean particle diameter of the second lithium metal composite oxide;

the first and second lithium metal composite oxides comprise a primary particle having a particle diameter distribution between about 0.1 μm and about 0.2 μm, and a secondary particle having a mean particle diameter distribution between about 1 μm and about 20 μm when the primary particles are aggregated to form the secondary particles; and

the first and second lithium metal composite oxides have a formula selected from the group consisting of

$$Li_{1+\delta}[Ni_xMn_{x-y/2}Co_{1-2x-z}M_yN_z]O_{2-a}P_a$$

and

$$Li_{1+\delta}[Ni_xMn_{x+y}Co_{1-2(x+y)}M_y]O_{2-a}P_a;$$

M is selected from the group consisting of Mg, Zn, Ca, Sr, Cu and Zr;

N is selected from the group consisting of Fe, Aℓ, Ga, In, Cr, Ge and Sn;

P is selected from the group consisting of F and S;

δ has a value such that $-1/10 \leq \delta \leq 1/10$;

x has a value such that $0 \leq x \leq 1$;

y has a value such that $0 \leq y \leq 1/10$;

z has a value such that $0 \leq z \leq 1/10$; and

a has a value such that $0 \leq a \leq 0.3$.

Claim 17 (canceled).

Claim 18 (previously presented): The method of Claim 16, wherein the composite cathode active material comprises about 5 wt% to about 40 wt% of the first lithium metal composite oxide.

Claim 19 (previously presented): The method of Claim 16, wherein the first lithium metal composite oxide has the same chemical composition as the second lithium metal composite oxide.

Claim 20 (currently amended): The method of Claim 16, wherein the composite cathode active material comprises at least two selected from the group consisting of nickel having an oxidation value of 2.0, manganese having an oxidation value of 4.0, and cobalt having an oxidation value of 3.0.

Claim 21 (previously presented): The method of Claim 16, wherein the first and second mixtures are exposed to ultrasonic energy.

Claim 22 (previously presented): The method of Claim 16, wherein:

the first metal precursor comprises a first aqueous metal solution containing more than two metal salts; and

the second metal precursor comprises a second aqueous metal solution containing more than two metal salts.

Claim 23 (previously presented): The method of Claim 16, wherein:

the first metal precursor comprises a first aqueous metal solution containing more than two metal salts;

the first aqueous ammonia solution has a concentration that is between about 0.2 and about 0.3 times a concentration of the first aqueous metal solution;

the second metal precursor comprises a second aqueous metal solution containing more than two metal salts; and

the second aqueous ammonia solution has a concentration that is between about 0.2 and about 0.3 times a concentration of the second aqueous metal solution.

Claim 24 (previously presented): The method of Claim 16, wherein the first and second mixtures each have a pH that is between about 11.0 and about 11.5.

Claim 25 (previously presented): The method of Claim 16, further comprising exposing the first and second lithium metal composite oxides to a chelating agent, wherein the chelating agent is selected from the group consisting of citric acid, stannic acid, glycolic acid and maleic acid.

Claim 26 (previously presented): The method of Claim 16, wherein:

the first and second metal precursors have the same chemical composition;

the first and second aqueous ammonia solutions have the same chemical composition;

the first and second basic solutions have the same chemical composition; and

the first and second lithium precursors have the same chemical composition.

Claim 27 (currently amended): A method for preparing a composite cathode active material for a lithium secondary battery, the method comprising:

producing a first lithium metal composite oxide by (a) precipitating a first metal composite hydroxide from a first mixture of a first metal precursor, a first aqueous ammonia solution and a first basic solution, and (b) mixing and reacting the first metal composite hydroxide with a first lithium precursor to form the first lithium metal composite oxide;

producing a second lithium metal composite oxide by (a) precipitating a second metal composite hydroxide from a second mixture of a second metal precursor, a second aqueous ammonia solution and a second basic solution, and (b) mixing and reacting the second metal composite hydroxide with a second lithium precursor to form the second lithium metal composite oxide; and

mixing the first and second lithium metal composite oxides to form a composite cathode active material for a lithium secondary battery; wherein

the first lithium metal composite oxide has a mean particle diameter that is less than 90% of a mean particle diameter of the second lithium metal composite oxide;

the first and second lithium metal composite oxides comprise a primary particle having a particle diameter distribution between about 0.1 μm and about 0.2 μm, and a secondary particle having a mean particle diameter distribution between about 1 μm and about 20 μm when the primary particles are aggregated to form the secondary particles; and

the first lithium metal composite oxide has a formula

$$LiNi_{1-x'-y}Co_{x'}M'_yO_2P_z;$$

the second lithium metal composite oxide has a formula selected from the group consisting of

$$Li_{1+\delta}[Ni_xMn_{x-y/2}Co_{1-2x-z}M_yN_z]O_{2-a}P_a$$

and

$$Li_{1+\delta}[Ni_xMn_{x+y}Co_{1-2(x+y)}M_y]O_{2-a}P_a;$$

M is selected from the group consisting of Mg, Zn, Ca, Sr, Cu and Zr;

M′ is selected from the group consisting of Aℓ, Mg, Zr and Ti;

N is selected from the group consisting of Fe, Al, Ga, In, Cr, Ge and Sn;

P is selected from the group consisting of F and S;

δ has a value such that $-1/10 \leq \delta \leq 1/10$;

x has a value such that $0 \leq x \leq 1$;

x' has a value such that $x' \leq 1/10$;

y has a value such that $0 \leq y \leq 1/10$;

z has a value such that $0 \leq z \leq 1/10$; and

a has a value such that $0 \leq a \leq 0.3$.

Claim 28 (previously presented): The method of Claim 27, wherein the first and second mixtures are exposed to ultrasonic energy.

Claim 29 (currently amended): A method for preparing a composite cathode active material for a lithium secondary battery, the method comprising:

producing a first lithium metal composite oxide by (a) precipitating a first metal composite hydroxide from a first mixture of a first metal precursor, a first aqueous ammonia solution and a first basic solution, and (b) mixing and reacting the first metal composite hydroxide with a first lithium precursor to form the first lithium metal composite oxide;

producing, separately from the first lithium metal composite oxide, a second lithium metal composite oxide by (a) precipitating a second metal composite hydroxide from a second mixture of a second metal precursor, a second aqueous ammonia solution and a second basic solution, and (b) mixing and reacting the second metal composite hydroxide with a second lithium precursor to form the second lithium metal composite oxide; and

after separately producing the first and second lithium metal composite oxides, mixing the first and second lithium metal composite oxides to form a composite cathode active material for a lithium secondary battery; wherein

the first lithium metal composite oxide has a mean particle diameter that is less than 90% of a mean particle diameter of the second lithium metal composite oxide;

the first and second lithium metal composite oxides comprise a primary particle having a particle diameter distribution between about 0.1 μm and about 0.2 μm, and a secondary particle having a mean particle diameter distribution between about 1 μm and about 20 μm when the primary particles are aggregated to form the secondary particles;

the first and second lithium metal composite oxides have a formula selected from the group consisting of

$$Li_{1+\delta}[Ni_xMn_{x-y/2}Co_{1-2x-z}M_yN_z]O_{2-a}P_a$$

and

$$Li_{1+\delta}[Ni_xMn_{x+y}Co_{1-2(x+y)}M_y]O_{2-a}P_a;$$

M is selected from the group consisting of Mg, Zn, Ca, Sr, Cu and Zr;

N is selected from the group consisting of Fe, Aℓ, Ga, In, Cr, Ge and Sn;

P is selected from the group consisting of F and S;

δ has a value such that $-1/10 \leq \delta \leq 1/10$;

x has a value such that $0 \leq x \leq 1$;

y has a value such that $0 \leq y \leq 1/10$;

z has a value such that $0 \leq z \leq 1/10$; and

a has a value such that $0 \leq a \leq 0.3$.

the reactor includes an agitator having a first set of rotary vanes designed to induce fluid flow in a first direction and a second set of rotary vanes designed to induce fluid flow in a second direction that is reverse from the first direction; and

the reactor further includes a plurality of baffles that are spaced apart from an inner wall of the reactor, have a shape of a flat panel and are attached to the inner wall by a plurality of connecting rods.